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A PONDEROSA PINE TREE CLASSIFICATION FOR USE IN DETERMINING SUSCEPTIBILITY TO BARKBEETLE ATTACK.

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One of the important considerations in the management of ponderosa pine timber lands is the reduction of the hazard of heavy loss from bark beetles. Such loss during the past two decades in the mature and overmature ponderosa pine stands of Oregon, Washington and California, has represented a major factor of forest depletion. The annual loss has run into billions of board feet and on a number of areas from 4 to 57 percent of the merchantable stands has been killed. If through management, the trees most likely to be killed by the beetles could be removed from the stand in advance of their destruction, an important step would be taken in the direction of reducing mortality and advancing the possibility of sustained yield forest production.

Selective cutting, in addition to its other silvicultural and economical advantages, offers the possibility of removing the more beetle susceptible trees and accomplishing the desirable objectives of (1) salvage of log values in trees which are not likely to remain alive for another cutting cycle, and (2) improvement in the vigor of reserve stand so as to enable the remaining trees to resist bark beetle attacks.

During the past decade, the relative susceptibility of ponderosa pines to beetle attack has received considerable study on the part of silviculturists and forest entomologists. As a result of these studies, it has been found that certain types of trees do offer a greater risk of being killed by bark beetles than do others in the stand. In general, the more susceptible trees are the weaker, less vigorous members of the stand and to a certain degree the older trees. The question then is one of recognizing these particular tree types.

Dunning[1], in the study upon which he based his tree classification, showed that the probability of insect loss was greatest in Classes 7, 5 and 4 when compared on the basis of basal area; while on the basis of number of trees, Classes 4, 2, 5

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1 Dunning, Duncan
1928 "A Tree Classification For The Selection Forests of the Sierra Nevada." Jour. Agr. Res. Vol. 36, No. 9, pp 755-771. May.

and 7 showed the highest risks in the order named. Person[2] verified these conclusions and found that the beetles showed a decided preference for slow-growing trees, particularly in the diameter classes between 20 and 30 inches and on the poorer sites. This preference he found was more marked during endemic than epidemic conditions. Further extensive studies in connection with surveys of pine stands in southern Oregon simply confirmed the earlier conclusions to the effect that Dunning's classes 7, 4, and 5 offered the greatest risk of beetle attack.

However, it was evident in the field that Dunning's seven broad tree classes tended to conceal differences in susceptibility within each class. It even seemed probable that there were certain types of trees within one class showing a greater disparity in relative risk to beetle attack than between different tree classes. Therefore, for the purpose of additional investigation, it seemed desirable to break down the Dunning tree classification into sub-classes in order to isolate the specific characters which were most important in indicating susceptibility. An expansion of Dunning's tree classification into 16 classes was adopted and used in the field for surveys and further studies. This classification may be called the "bark beetle susceptibility classification" and is described below.

DESCRIPTION OF THE BARK BEETLE SUSCEPTIBILITY CLASSIFICATION

This tree classification, illustrated by the accompanying chart, is based primarily upon the two major factors of age and vigor. It is particularly applicable to the ponderosa pine forests of the Pacific region. Four age groups are recognized and numbered 1 to 4; and four degrees of crown vigor are lettered A to D. Combining these two factors gives 16 possible classes into which any ponderosa pine in the stand may be placed.

Age Groups

Trees are first divided into the four general age groups of young, immature, mature and overmature. In the average Site IV ponderosa pine stand of the Pacific region, the characteristics of each of these age groups are as follows:

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2 Person, H. L.
1928 "Tree Selection by the Western Pine Beetle." Jour. For. Vol. XXVI No. 5, pp. 564-478. May.

1. Young trees - commonly referred to as "bull pines" or "blackjacks"; usually less than 75 years of age, with dark-brown to black, deeply ridged bark; tops usually pointed and branches upturned and in whorls.

2. Immature trees - Age approximately 75 to 150 years; trees still making height growth and with pointed tops; reddish-brown, fissured bark; branches mostly upturned and in whorls.

3. Mature trees - approximately 150 to 300 years old; usually with rounded or pointed tops; bark light reddish-brown with moderately large plates between the fissures; incomplete whorls of branches with nodes indistinct; nearly all branches horizontal and the lower ones drooping.

4. Overmature trees - usually over 300 years old; with flat tops and making no further height growth; branches mostly drooping, gnarled or crooked; bark light yellow in color, the plates usually very wide, long and smooth.

In dividing the trees into these four general age classes it is more important to consider what might be called the "physiological age" of the tree than its actual age as indicated by annual rings. Some trees growing under favorable conditions, particularly on good sites, retain their youthful appearance much longer than do trees on poor sites which have been forced to struggle against unfavorable growth conditions. Since the four age groups are a matter of relative maturity, trees somewhat younger or older than the designated age limits but having all of the outward characteristics of a certain age group should be classified accordingly.

Vigor Groups

In judging the relative vigor of different trees of a given age, the size of crown and abundance of foliage is probably the best outward indicator. Therefore, each age class was further subdivided into four sub-groups based upon relative crown vigor. These were designated by letters A to D as follows:

A. Full vigorous crowns with a length of 55 percent or more of the total height and of average width or wider; foliage usually dense; needles long and dark green; position of tree isolated or dominant (rarely codominant).

B. Fair to moderately vigorous crowns with average width or narrower, and length less than 55 percent of the total height; either short wide crowns or long narrow

ones, but not sparse nor ragged; position, usually codominant but sometimes isolated or dominant.

C. Fair to poor crowns, very narrow and sparse or represented by only a tuft of foliage at the top; foliage usually short and thin; position usually intermediate, sometimes codominant, rarely isolated.

D. Crowns of very poor vigor; foliage sparse and scattered or only partially developed; diameters decidedly subnormal considering age; position suppressed or intermediate.

Thus by combining the four age groups with the four subgroups of crown vigor, a total of sixteen classes was obtained which could be analyzed for relative susceptibility.

According to definition, the comparison between the expanded classification and Dunning's classification is as follows:

Dunning's Classification	Bark beetle Susceptibility Classification
Class 1	Classes 1A, 2A
Class 2	Classes 1B, 2B
Class 3	Class 3A
Class 4	Classes 3B, 3C
Class 5	Classes 4A, 4B, 4C
Class 6	Classes 1C, 2C, 1D, 2D
Class 7	Classes 3D, 4D

Or in reverse order:

Bark beetle Susceptibility Classification		Dunning's Classification
Age Group	Vigor Group	
1	A, B, C, D	1, 2, 6, 6
2	A, B, C, D	1, 2, 6, 6
3	A, B, C, D	3, 4, 4, 7
4	A, B, C, D	5, 5, 5, 7

RELATIVE SUSCEPTIBILITY OF THE TREE CLASSES

During a four year period, 1928 to 1931, on bark beetle surveys in southern Oregon and northern California, a total of 27,465 beetle killed trees approximately 16,000 acres of sample plots were classified under this system and a similar sample of 22,428 green trees taken for comparison. This study showed the comparative apportionment of the different tree classes in the virgin stand and the distribution of the beetle killed trees between the classes. The results are shown in the following table:

Table I
Relative Tree Susceptibility

	Tree Class	Apportionment in Trees: Total Stand %	Apportionment in Trees: Beetle-killed %	Ratio of Mortality to Stand	Relative Susceptibility Rank
1.	A	9.4	1.5	.15	16
	B	5.6	2.5	.44	13
	C	2.4	3.8	1.69	5
	D	.2	.5	2.50	2
2.	A	9.1	2.8	.30	15
	B	9.8	9.5	.97	11
	C	5.5	14.1	2.58	1
	D	1.4	1.8	1.28	8
3.	A	8.5	3.5	.39	14
	B	10.5	11.7	1.11	10
	C	7.7	13.1	1.72	4
	D	2.9	4.0	1.36	7
4.	A	9.1	4.3	.47	12
	B	10.1	11.6	1.22	9
	C	5.6	12.4	2.38	3
	D	2.2	2.9	1.45	6

The ratio of occurrence of beetle losses in the various tree classes, as compared with the apportionment of total green trees found in each class, indicates whether or not any particular tree class is favored by the beetles in making their attack. Thus, if 9% of the green trees are found in Class 2B, and 9% of the killed trees are also found in that class, the ratio will be 1.00, which indicates no particular preference. Ratios above 1 indicate that such types are more frequently found among the killed trees and are susceptible, while ratios below 1 indicate corresponding immunity. Therefore the more susceptible classes and the more resistant ones are as follows:

Susceptible Types

Class	Ratio
2C	2.58
1D	2.50
4C	2.38
3C	1.72
1C	1.69
4D	1.45
3D	1.36
2D	1.28
4B	1.22
3B	1.11

Resistant Types

Class	Ratio
1A	.15
2A	.30
3A	.39
1B	.44
4A	.47
2B	.97

It will be noted that all of the "A" crowns and the "B" crowns of the younger trees fall within the resistant types, while the "C" and "D" crowns of all ages are susceptible. In other words, the bark beetles, under average conditions, select the intermediate and suppressed trees

of all age classes, and in this respect act as Nature's silvicultural agents in thinning the stands of the weaker individuals and the leaving of the stronger dominants. Unfortunately during period of critical growth conditions, they carry their normal activities too far. When bark beetle epidemics develop, the selective tendencies become less marked and all types of trees except the youngest and thriftiest may be killed.

One very obvious characteristic of western pine beetle infestations is the tendency to select trees of intermediate, codominant and suppressed crown development which are growing in groups, while isolated trees are much less frequently taken. This suggests that spacing may be a very important consideration, especially during drought conditions when group-wise trees are forced to compete with each other for whatever soil moisture there may be within their root-feeding zone. During such periods, large groups on normally good sites may suffer from a more critical shortage of moisture than widely spaced trees on poor sites, which are adjusted to a perennially inadequate supply. This may be one of the reasons why group infestation is so characteristic of outbreaks on the better sites, while on poor sites infestations are usually more widely dispersed, both in groups and in isolated trees.

APPLICATION TO MARKING PRACTICE

Since the types of trees most susceptible to bark beetle attack can now be recognized with a fair degree of certainty, it is possible to include these types in the first cut. Such removal should accomplish one or both of two objectives - first, the salvage of valuable trees which have a small chance of lasting until the next cut; and secondly, the reduction of the chances of a disastrous bark beetle outbreak through the removal of the trees most likely to harbor infestations.

Present marking practice, in the ponderosa pine forests of the National Forests and Indian Reservations of this region, which removes approximately 80 percent of the mature and over-mature stands, so nearly eliminates all types of beetle susceptible trees that the problem of salvaging values and reducing the threat of further beetle losses is usually solved. Under this more or less standard marking practice, all trees of high beetle risk, except a few intermediate and suppressed trees of small diameter have been marked for cutting.

Under a system of light selection cutting, if in the first cut a smaller volume of timber is to be removed over a larger acreage, then the question of relative beetle risk becomes more important. Trees of the highest risk obviously should be removed in the first cut. The marking, therefore, should include as many trees of the more susceptible types as can be removed, while taking into account merchantability and silvicultural requirements.

From the insect hazard standpoint, a desirable marking would be a "vertical" selection through all age classes taking out the intermediate, suppressed and codominant trees of poor vigor, and thinning the groups. A "horizontal" selection designed to take out the older over-mature trees, or trees above a given diameter limit would not be effective in reaching a high percentage of beetle susceptible material, even though such a selection would undoubtedly yield higher log values. There is a need, therefore, to balance the various considerations of silvicultural requirements, merchantability and mortality risks in reaching the final decision as to which trees should be marked.

While a stand which has been thinned of the more susceptible trees should in all reason be in better shape to resist bark beetle epidemics, there is no assurance that such stands will be immune to further losses. During period of bark beetle epidemics, trees of all classes may be killed with little regard to apparent vigor. Also in "fringe type" timber or on areas suffering from the effects of drought, all types of trees are reduced in vigor and resistance to bark beetle attack, and tend to become nearly equal in susceptibility. There are many examples to show that on the poorer sites and in fringe type timber, it is futile to leave as a reserve any but the youngest and most vigorous trees.

Improvement of growth conditions in a stand and the reduction of mortality are two very closely related phases of silvicultural management, and the measures necessary to accomplish these objectives are similar in every respect. The types of trees which should be cut from the growth improvement standpoint are also those which should be removed in order to reduce mortality. While selection cuttings may not solve the problem of all future bark beetle damage, they are at least a step in the right direction of improving the chances of ponderosa pine stands to escape such injury. Thus, in large measure, the solution of the pine beetle problem lies in the application of the principles of good silviculture.

A PONDEROSA PINE TREE CLASSIFICATION —

FOR COMPARISON OF BARKBEETLE SUSCEPTIBILITY
CLASSES BASED ON AGE AND VIGOR